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Internal and external rotation strength values of female swimmers and water polo players

Christopher Ferry
San Jose State University

INTERNAL AND EXTERNAL ROTATION STRENGTH VALUES

OF FEMALE

SWIMMERS AND WATER POLO PLAYERS

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Christopher Ferry

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APPROVED FOR THE DEPARTMENT OF HUMAN PERFORMANCE

Leamor Kahanov

Kyle Bodyfelt

Dava Reeder

APPROVED BY THE UNIVERSITY

ABSTRACT

INTERNAL AND EXTERNAL ROTATION STRENGTH VALUES OF FEMALE SWIMMERS AND WATER POLO PLAYERS

by Christopher Ferry

Rehabilitation programs for swimmers and water polo players with shoulder injuries have historically been identical, yet there exists inherent biomechanical and training differences between the two sports. The purpose of this study was to determine if a shoulder strength difference exists between swimmers and water polo players. Twenty-five subjects (10 swimmers and 15 water polo players) performed an isokinetic test on the Biodex, System 2. The subjects were tested in two different arm positions (45 and 90 degrees of shoulder abduction in the scapular plane) and three different speeds (60, 240, and 450 degrees/second). Mann-Whitney non-parametric tests were calculated on the tests in 90 degrees of shoulder abduction at a speed of 450 degrees/second speeds for peak torque and total work. No statistically significant differences between the two sports were found, however, the swimmers showed a higher mean on 22 of the 24 tests performed. Practically, 3 of the 4 tests indicated visible differences suggesting that individual rehabilitation programs for shoulder injuries need to be designed separately and specifically for swimmers and water polo players.

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OF FEMALE

SWIMMERS AND WATER POLO PLAYERS

By

Christopher Ferry
San Jose State University

Leamor Kahanov
San Jose State University
Program Director-Graduate Athletic Training
One Washington Square
San Jose, CA 95192-0054
408-924-3040
leamor@email.sjsu.edu

Kyle Bodyfelt
San Jose State University

Dava Reeder
Stanford University

Christopher Ferry

Leamor Kahanov

Kyle Bodyfelt

Dava Reeder

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ABSTRACT

INTERNAL AND EXTERNAL ROTATION STRENGTH VALUES OF INTERCOLLEGIATE FEMALE SWIMMERS AND WATER POLO PLAYERS

Objective - The objective of this study was to determine shoulder strength differences between female swimmers' and water polo players' internal and external rotation peak torque and total work values.

Design and Setting - Subjects performed an isokinetic test on the Biodex, System 2. The subjects were tested in two different arm positions (45 and 90 degrees of shoulder abduction) and three different speeds (60, 240, 450 degrees/second).

Subjects - Ten female swimmers and 15 female water polo players from a Division I university.

Measurements - Four Mann-Whitney non-parametric tests were calculated on the test scores in internal and external rotation in 90 degrees of shoulder abduction at 450 degrees/second examining peak torque and total work. Demographic data was also summarized using means and standard deviations.

Results - No statistical significance was present between these populations. A moderate level of practical significance was present. A comparison of the means showed that the swimmers had an increased strength value on 22 of the 24 tests.

Conclusions - Swimmers were identified as stronger than the water polo players. Practically, 3 of the 4 statistical tests indicated visible differences suggesting individual rehabilitation programs for shoulder injuries need to be designed separately and specifically for swimmers and water polo players

Key Terms - Shoulder strength, internal rotation, external rotation, isokinetic testing device, scapular plane

Shoulder injuries have been cited as one of the major reasons for time loss in competitive swimmers.[1] Elite level swimmers and water polo players endure similar training schedules, relying primarily on free-style swimming for conditioning, creating repetitive overhead shoulder movements that can frequently lead to overuse injuries and soft tissue micro-trauma.[1] Two main orthopedic problems in these populations appear to be a combination of impingement and instability, lending to labral changes and increased glenohumeral laxity.[2-5] Historically, shoulder rehabilitation programs have been similar for water polo and swimming, however, inherent differences between the two sports may indicate the need for modified shoulder rehabilitation protocols. For instance, compared to swimming stresses alone in swimmers, water polo stresses are a combination of swimming and throwing activities.[2]

Standard strength values have been used as baselines for injury goals during the rehabilitation of joints such as the knee and ankle.[10, 11, 12] Standard internal and external rotation strength values could be used in the rehabilitation programs for swimmers and water polo players, however, preliminary studies of the rotator cuff between these sports indicate differences in strength.[1, 6, 8, 9] Male water polo players have been found to have significantly stronger rotator cuff strength and a muscle imbalance between internal and external rotation[9] compared to swimmers who have no statistical side-to-side strength differences.[1] The limited amount of research regarding internal and external rotation strength levels in water polo players and swimmers, questions current rehabilitation and prevention practices for these athletes. Studies have suggested a difference between internal and external rotation of water sports and other overhead activities[5, 9, 12]; though no studies have examined female swimmers and water polo players to determine internal and external rotation strength differences in these two sports.

The purpose of this study is to examine the internal and external rotation peak torque and total work of elite female swimmers and water polo players to determine if strength differences exist between these two sports. This data can potentially be used as baselines/goals for female swimmers and water polo players during the rehabilitation of shoulder injuries.

METHODS

SUBJECTS

Fifteen female collegiate varsity swimmers and ten female collegiate varsity water polo players (n=25) from a Division 1A university were chosen to serve as subjects. All subjects signed a consent form prior to testing that was approved by the human subjects committee at San Jose State University and Stanford University. Each subject had their dominant shoulder tested. Hand dominance was determined in the water polo players by the arm with which the individual throws with and in the swimmers by the hand with which the individual writes. Subjects were excluded if they suffered from an existing shoulder injury or have had a significant shoulder injury requiring extensive rehabilitation or surgery in the past year (12 months).

PROTOCOL

Each subject was tested for peak torque and total work in internal rotation and external rotation on the Biodex, System 2 isokinetic testing device (Medical Systems Inc., Shirley, New York). The Biodex, System 2 was calibrated regularly during testing according to the set standards in the Biodex, System 2 handbook. The subjects were tested at 60 degrees per second, 240 degrees per second, and 450 degrees per second in the scapular plane[7] and at 45 and 90 degrees of shoulder abduction. Subjects were tested twice to determine reliability with a minimum of one day between testing.

All subjects were tested in loose-fitting clothes (athletic shorts and T-shirts) to eliminate shoulder restrictions during testing. The subjects were then positioned into the Biodex after an initial warm-up was completed.

Each subject was tested in the seated position while secured to the chair on the Biodex, System 2. The subjects were secured to the chair with straps across the waist and across the tested shoulder to ensure no accessory trunk movement. The tested arm was placed into the dynamometer with the shoulder internal and external rotation attachment on the Biodex, System 2 according to the testing protocol. The elbow was stabilized with velcro straps and flexed to 90 degrees. The uninvolved arm remained in the neutral position at the subject's side during testing.

Verbal instructions explaining the testing procedure were given. Each subject was given a countdown from 3 before the start of each test. Verbal cues were also given to the subject to encourage maximum effort. Each subject performed concentric contractions of internal rotation and external rotation at each test speed and degree of shoulder abduction. Internal rotation was measured from the arm in the plane of the scapula until it approximates with the trunk and external rotation was measured from the arm in the plane of the scapula until it reaches its anatomical limit. The subjects performed 5 repetitions at 60 degrees per second, 15 repetitions at 240 degrees per second and 15 repetitions at 450 degrees per second. Both of these sets were tested at 45 and 90 degrees of shoulder abduction with a one-minute rest period between all tests.

All data was collected and stored in the Biodex, System 2 computer. Confidentiality was maintained indicating only the subjects' sport and gender on the data sheets. The Biodex, System 2 computer was used to print the record and each data sheet. Each data sheet was then identified solely as a swimmer or water polo player.

Descriptive statistics were used to determine the mean and standard deviation of the peak torque and total work values produced by each muscle group (internal/external rotators) of the dominant shoulder at each speed and degree of shoulder abduction. Demographic data (height, weight, and age) was also reported. Four Mann-Whitney tests were performed (internal/external rotators) to compare the peak torque and total work values of the two sports' athletes.

RESULTS

Both teams were similar with respect to height, weight, and age. The assumptions for the independent t-test (normality) were violated, therefore, four non-parametric Mann-Whitney tests were performed to differentiate the internal and external rotation peak torque and total work values between the swimmers and water polo players. An alpha level of 0.0125 was used (α=0.05/4 tests). Four isokinetic tests used were at 90 degrees of shoulder abduction with a speed of 450 degrees per second in internal and external rotation. The first two tests examined peak torque while the last two tests examined the total work performed. This test position was used because it provided the most functional arm position and speed that the athletes experience during regular activities. The results of the Mann-Whitney tests were compared to the p value and were not found to be statistically significant. However, when the means of the tests were compared, the swimmers showed a higher mean score on 22 of the 24 tests performed (see Table 1 and 2). Reliability coefficients were calculated on the peak torque and total work values of internal and external rotation between the first and second tests. The internal rotation peak torque values had a reliability coefficient of 0.829 while the external rotation peak torque values had a reliability coefficient of 0.4244. The internal rotation total work values had a reliability coefficient of 0.832 while the external rotation values had a reliability coefficient of 0.8724. These values indicate that the data was stable across measures. The results indicate a moderate level of practical significance. These values of practical significance were 0.43 for the peak torque/internal rotation test, 0.07 for the peak torque external/rotation test, 0.54 for the total work/internal rotation test, and 0.62 for the total work/external rotation test. Power was calculated and determined to be very low (< 0.30) in this study.

CONCLUSIONS

Although the results were not found to be statistically significant, a moderate level of practical significance was present. The data indicates that the swimmers have higher mean peak torque and total work value for both internal and external rotation compared with the water polo players. This is the first study to compare swimming and water polo rotator cuff strength values. Previous studies have examined elite swimmers and water polo players and compared their subjects to a control group[1,9], which does not allow for comparisons between sports or rehabilitation protocols for individual sports.

The purpose of this study was to determine if a difference exists between swimming and water polo athlete rotator cuff strength. Results indicate a practical difference between both groups. Swimmers have a stronger rotator cuff suggesting that rehabilitation goals for strength should be higher than water polo players comparatively. Rehabilitation programs should look at the different function of the two sports to specifically target the needs of the swimmers and water polo players individually. The ideology that the "swimming athlete" should be rehabilitated in the same manner should be modified. In addition, shoulder strength of water polo players has the added functional component of throwing, which should also be incorporated into water polo shoulder rehabilitation programs.

Several variables may have had an influence on the variability of the external rotation/peak torque test including: the number of years that the subject has participated in their respective sport, the stroke and distances specific to the swimmers or the position played on the water polo team and the previous experience of the water polo player. Many water polo players have a strong swimming background. These uncontrolled variables may have effected the outcome of the study.

RECOMMENDATIONS FOR FURTHER STUDY

Several issues in this study may have influenced the outcome of the study and should be addressed in future research. Even though the subject was secured to the Biodex, System 2, there was no exceptional way to immobilize the elbow during testing, particularly at 90 degrees of shoulder abduction. Subjects did not follow the same warm-up protocols. Some subjects were tested following a practice session and some performed the warm-up on the UBE. Also, a larger sample size may influence the end results.

Finally, more studies need to be conducted, including EMG analysis of the shoulder, to assess trunk stability between swimming and water polo athletes to create more comprehensive and accurate rehabilitation protocols.

Table 1. Peak Torque Means and Standard Deviations for Swimmers and Water Polo Players

	Swimmers (n=10)		Water Polo (n=15)	
Test Peak Torque	Mean (ft./lbs.)	Standard Deviation	Mean (ft./lbs.)	Standard Deviation
45° Abduction IR 60°/sec	30.78	3.77	30.43	5.99
45° Abduction IR 240°/sec	31.95	4.84	29.90	5.05
45° Abduction IR 450°/sec	36.04	5.30	34.63	5.26
45° Abduction ER 60°/sec	15.47	6.58	13.38	3.33
45° Abduction ER 240°/sec	15.34	6.21	13.81	3.02
45° Abduction ER 450°/sec	16.18	7.57	15.27	2.87
90° Abduction IR 60°/sec	32.67	4.75	30.15	4.93
90° Abduction IR 240°/sec	32.91	4.83	30.76	5.41
90° Abduction IR 450°/sec	38.18	5.51	35.50	6.89
90° Abduction ER 60°/sec	12.61	3.59	13.06	3.25
90° Abduction ER 240°/sec	12.43	4.37	11.44	3.65
90° Abduction ER 450°/sec	14.43	3.74	14.13	3.89

Table 2. Total Work Means and Standard Deviations for Swimmers and Water Polo Players

Test Total Work	Swimmers (n=10) Mean (ft./lbs.)	Swimmers (n=10) Standard Deviation	Water Polo (n=15) Mean (ft./lbs.)	Water Polo (n=15) Standard Deviation
45° Abduction IR 60°/sec	202.48	54.61	184.52	45.38
45° Abduction IR 240°/sec	505.64	158.43	427.27	97.11
45° Abduction IR 450°/sec	450.41	150.16	376.18	81.03
45° Abduction ER 60°/sec	89.22	62.31	68.81	19.23
45° Abduction ER 240°/sec	126.86	43.57	112.62	35.04
45° Abduction ER 450°/sec	149.76	125.21	105.17	28.72
90° Abduction IR 60°/sec	209.15	45.71	192.96	31.65
90° Abduction IR 240°/sec	523.96	176.02	474.56	99.03
90° Abduction IR 450°/sec	476.82	153.83	411.04	91.88
90° Abduction ER 60°/sec	75.43	36.73	87.17	107.89
90° Abduction ER 240°/sec	130.72	98.17	102.46	55.80
90° Abduction ER 450°/sec	127.95	81.24	90.24	39.76

Table 3. Demographic Information of Swimmers and Water Polo Players

	Swimmers (n=10)		Water Polo (n=15)	
	Mean	Standard Deviation	Mean	Standard Deviation
Height (cm)	176.28	7.21	176.07	6.12
Weight (kg)	331.32	30.23	345.49	35.07
Age (years)	19.10	1.37	19.24	1.16

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INTERNAL AND EXTERNAL ROTATION STRENGTH VALUES OF FEMALE SWIMMERS AND WATER POLO PLAYERS

Chapter I

Introduction

Swimmers use their shoulders in an overhead position up to 11,000 times per week of training (Magnusson, Constantini, McHugh, & Gleim, 1995). Thus, shoulder injuries have been cited as one of the major reasons for time loss in competitive swimmers (Magnusson et al., 1995). Elite level swimmers and water polo players use swimming as the main concentration of practice in addition to specific event/sport training. These athletes may not be able to practice if they are sidelined with an injury, and rehabilitating an athlete back to practice entails strengthening the shoulder musculature. The repetitive nature of swimming can frequently lead to soft tissue microtrauma (Magnusson et al., 1995). The difficulty in rehabilitating swimmers and water polo players is that there are no standard strength values available to set goals and determine baselines for these athletes. Thus, return of these athletes to participation has been historically subjective.

Numerous studies have focused on the isokinetic analysis of the rotator cuff and how these muscles function in shoulder movement (Bak & Magnusson, 1997; Brown, Niehues, Harrah, Yavorsky, & Hirshman, 1988; Chandler, Kibler, Stracener, Ziegler, & Pace, 1992; Hageman, Mason, Rydlund, & Humpal, 1989; Hartsell & Forwell, 1997; Hinton, 1988; Jenp, Malanga, Growney, & An, 1996; Kramer & Hg, 1996; Magnusson et al., 1995; McMaster, Long, & Caiozzo, 1992; McMaster, Long, & Caiozzo, 1991; Perrin, Robertson & Ray, 1987; Tis & Maxwell, 1996). The strength, and endurance of the rotator cuff are the emphasis of these studies. Many different athletic populations, such as swimmers, water polo players, tennis players, and baseball players have been examined (Hinton, 1988; Mont, Cohen, Campbell, Gravare, & Mathur, 1994). There are multiple studies that examine swimmers and water polo players (Bak & Magnusson, 1997; Magnusson et al., 1995; McMaster et al., 1992; McMaster et al., 1991); however, there is limited research available that compares the differences of internal and external rotation strength values of swimmers and water polo players. Magnusson et al. (1995) states that guidelines of absolute strength values of internal and external rotation should be set for rehabilitation purposes for both swimmers and water polo players..

Standard internal and external rotation strength values can be used as baselines and goals for injury rehabilitation programs for swimmers and water polo players during rehabilitation of an injury. The strength of the uninvolved upper extremity can serve as a rehabilitation goal of the injured athlete, and is extremely important when pre-injury data is not available to the clinician treating the athlete (Magnusson et al., 1995). The uninvolved extremity can be used as return to sport goals for rehabilitation; however, the influence of handedness and neuromuscular demands of bilateral muscle group relationships of the involved sport raises question as to the efficacy of this prescription process (Perrin et al., 1987). For these reasons, pre-injury data needs to be available for all sports.

Water polo is the most physical of the water sports combining the components of swimming and overhead throwing athlete (Dominguez, 1986). Orthopedic injuries associated with this sport are a combination of the stress of swimming and the overuse syndromes inherent to that sport and injuries common to the throwing motion

(Dominguez, 1986). This combination of shoulder actions makes treatment of shoulder injuries much more difficult in the water polo player (Dominguez, 1986). Swimming does not contain the throwing action or the level of physicality that water polo possess, however, due to similarities of these two sports, athletic injuries and rehabilitation of the shoulder are treated the same. The inherent differences between the two sports warrants different rehabilitation protocols for injured shoulders; therefore, rehabilitation protocols should be designed specifically for each sport. Currently, no literature exists that examines the differences in shoulder strength between swimmers and water polo players so it is difficult for the athletic trainer to set appropriate rehabilitation protocols.

Purpose of this Project

The purpose of this study is to examine the internal and external rotation strength of elite female swimmers and female water polo players and to assess differences in the internal and external rotation peak torque and total work values of these sports.

Significance of the Study

No studies have been done that compare strength values of internal and external rotation for female swimmers and female water polo players. This data may be used to determine strength baselines and rehabilitation goals when setting injury rehabilitation programs for female swimmers and water polo players.

Delimitations

The study was delimited by the number of subjects, the age of the subjects, the level of competition of the subjects, the exclusion of injured shoulders, the sports involved, the speeds of measurement, the angles of measurement, and the tool of measurement (Biodex, System 2). The Biodex, System 2 is the only isokinetic tool available to the test practitioner and is only able to test at certain speeds and degrees of shoulder abduction. Also, the position and testing speeds of the Biodex, System 2 are not truly sport specific to the sports being examined.

Limitations

The main limitation of the study is that the subjects being tested may not perform to their true potential due to repetitions during the study, practice, or previous muscle soreness.

Assumptions

This study assumes that all of the athletes of the same sport endure similar training schedules. In addition, it is assumed that the Biodex, System 2 will accurately calibrate and record the data.

Statement of Hypothesis

The null hypothesis of this study is that there is no significant difference of internal rotation and external rotation peak torque and total work values between female swimmers and water polo players.

Definition of Terms

Glenohumeral Joint - A multiaxial , ball-and-socket, synovial joint that relies on muscles for support, stability, and integrity rather than bones or ligaments (Magee, 1997).

Overhead Athlete – Sport actions that take place at over 90 degrees of shoulder abduction.

Isokinetic Testing Device – A device that can test at varying or accommodating resistance while remaining at a constant speed.

Force Couple – Two groups of muscles that have opposing actions contracting synchronously to enable a specific motion to occur.

Eccentric Contraction – Muscle contraction that occurs while the muscle is lengthening.

Concentric Contraction – Muscle contraction that occurs while the muscle is shortening.

Power – Equal to force over time.

Scapular Plane - Thirty degrees of lateral adduction of the glenohumeral joint (Magee, 1997).

Chapter II

Review of the Literature

The purpose of this section is to review the literature pertaining to this study. The review will be divided into the following sections: 1) shoulder complex anatomy, 2) examination of overhead athletes, and 3) examination of swimmers and water polo players.

Shoulder Complex Anatomy

There are numerous anatomical structures that make up the shoulder complex. The glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic joints comprise the shoulder complex and work in conjunction to allow shoulder movement (see Figure A and B).

Figure A.

Shoulder complex anatomy - anterior

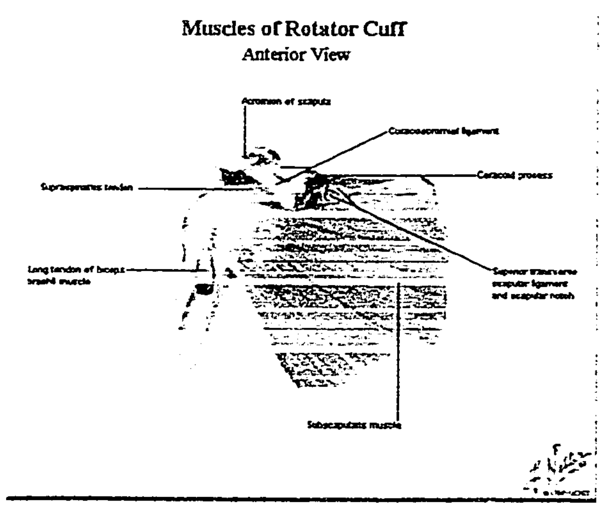
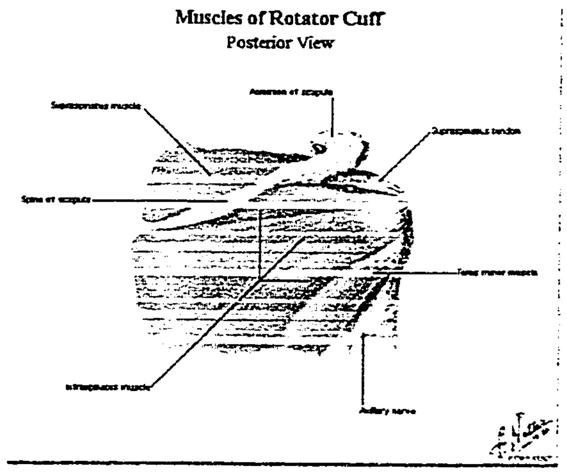


Figure B.

Shoulder complex anatomy - posterior



The anatomical structures contribute to the stability of the glenohumeral joint, including the passive restraints (osseous, labrum, ligamentous) and the active restraints [neuromuscular system) (Wilk, Arrigo, & Andrews, 1997). It is the interaction of these structures which provide functional glenohumeral joint stability (Wilk et al., 1997).

The glenohumeral joint is inherently unstable and exhibits the greatest amount of motion of any joint in the human body (Wilk et al., 1997). Stabilization of the humeral head within the glenoid fossa is extremely important because of the laxity of the joint. Stabilization is accomplished through the combined efforts of the ligamentous structures and surrounding shoulder musculature (Wilk et al., 1997).

The primary active stabilizers of the glenohumeral joint include the rotator cuff muscles (supraspinatus, infraspinatus, subscapularis, and teres minor), the deltoid, and the long head of the biceps brachii (Wilk et al., 1997; Tsai et al., 1991). Wilk et al.

(1997) also states that the primary role of these muscles is the production of a combined muscular contraction. A force couple between the rotator cuff and the deltoid stabilizes the humeral head within the glenoid fossa during overhead motions (Wilk et al., 1997, Hart & Carmichael, 1985; Magnusson et al., 1995). The function of the rotator cuff is to dynamically rotate the humerus, depress the humeral head to clear the acromion and to both actively and passively provide glenohumeral joint stability (Chandler et al., 1992; Hinton, 1988; Jenp et al., 1996). The deltoid is the prime mover of shoulder abduction, but cannot work effectively in the absence of the rotator cuff muscles (Schenkman & Rugo De Cartaya, 1987). The rotator cuff prevents superior movement of the humeral head into the subacromial arch permitting the humeral head to clear the acromion and allow for abduction of the arm (Schenkman & Rugo De Cartaya, 1987).

The glenohumeral joint is a multi-axial joint that allows for a range of motion in all directions. The shoulder complex functions as a kinetic chain composed of three distinct segments. Movement in any one segment may produce movement in other segments (Schenkman & Rugo De Cartaya, 1987); for example, movement of the humerus through action of the latissimus dorsi or pectoralis major will produce movement of the scapula and clavicle. The supporting structures, passive and active restraints, of the glenohumeral joint are very important in maintaining shoulder stability, due to these accessory movements.

The scapulothoracic musculature also plays a significant role in shoulder biomechanics by maintaining an optimum position as well as a stable base of support from which the glenohumeral muscles fixate and function (Wilk et al., 1997 and Tsai et al., 1991). The three primary roles of the scapula are to increase the positions available for the hand in space by varying the original position of the proximal humerus, to provide stability of the upper extremity during functional activities and to provide attachments for the four muscles of the rotator cuff (Hart & Carmichael, 1985). Tsai et al. (1991) states that since virtually all arm movement is antigravity, direct muscle control is of great importance for shoulder function.

Use of the shoulder in overhead activity synchronized active contraction of the rotator cuff to depress the humeral head and allow for internal and external rotation without impingement of the rotator cuff tendon under the subacromial arch. Lack of rotator cuff strength will allow the humeral head to decrease the subacromial space and increase the potential for a rotator cuff injury. Thus, it is evident in swimmers and water polo players who have repetitive overhead activity, that the rotator cuff strength and endurance is imperative. However, the standard strength and endurance values for internal and external rotation of the shoulder are not yet known.

Examination of Overhead Athletes

Athletes involved in sports which require repetitive overhead motion, such as swimmers and throwers, place increased stresses on the rotator cuff as compared to athletes who do not require this movement, since the rotator cuff is constantly contracting to limit the amount of humeral head elevation under the subacromial arch. The glenohumeral joint is in a loose packed, or unstable position, above 90 degrees of shoulder abduction (Hart & Carmichael, 1985). Because the glenohumeral joint is unstable in this position, the rotator cuff must continue to stabilize the humeral head within the glenoid fossa.

Muscle strains, tendonitis, and secondary shoulder impingement are three of the most common shoulder overuse injuries (Copeland, 1993). Athletes who use their muscles in a non-synchronous manner are predisposed to overuse injuries (Bradley & Tibone, 1991). Rotator cuff injuries may occur due to an inequality of strength of the internal and external rotators causing abnormal firing patterns which lead to these injuries (Copeland, 1993; Magnusson et al., 1995; Chandler et al., 1992).

Hinton (1988) examined amateur baseball pitchers and found significant internal and external rotation strength imbalances between the throwing and non-throwing arms. Hinton also found that peak torque (see Table 4) and total work (see Table 5) for the throwing side internal rotators were significantly higher than the non-throwing side in all tests.

Table 4.

Mean Rotational Peak Torque Value (ft./lbs.) and Standard Deviations for Internal and External Rotation

	Dominant (pitching) Shoulder		Nondominant Shoulder	
	Neutral TP	90 ° AbTP	Neutral TP	90° AbTP
90 deg/sec				
Internal	30.7± 5.2	29.1 ±5.5	26.1 ±5.1	25.7 ±6.4
External	18.5 ±3.1	19.8 ±4.2	17.0 ±3.2	19.3 ±4.5
240 deg/sec				
Internal	22.5 ±6.2	20.4 ±5.9	19.2 ±4.9	18.5 ±5.3
External	12.2 ±3.1	14.5± 4.0	11.7 ±2.6	14.5 ±3.7

Note. From Hinton, 1988

Table 5.

Mean Rotational Total Work Values (ft./lbs.) for Internal and External Rotation

	Dominant (pitching) Shoulder		Nondominant Shoulder	
	Neutral TP	90° AbTP	Neutral TP	90° AbTR
Internal	109.6± 33.5	92.7± 29.7	93.9 ± 29.9	87.5 ± 31.2
External	51.4± 17.1	60.7± 18.4	48.3± 19.3	62.0± 20.4

Note. From Hinton, 1988

Professional baseball players were not found to follow the same trend. Baseball players have equal rotation ratios at all speeds tests (Brown et al., 1988). These two conflicting studies demonstrate that high-level athletes may counteract muscle imbalances by specifically targeting the external rotators during training. Elite swimmers and water polo players may also counteract these muscle imbalances, but no literature is available to confirm these findings.

Chandler et al. (1992) tested collegiate tennis players and found the subjects produced significantly more torque in internal rotation in the dominant arm compared to the non-dominant arm, but there were no side-to-side differences seen in external rotation. Due to the increased internal rotation strength without subsequent external strength, these authors state that muscle imbalances may occur which could increase the likeliness of overload injuries since the external rotators can not adequately decelerate the arm.

Baseball and tennis players show many of the same internal and external rotation characteristics that swimmers and water polo players exhibit; however, the same conclusions cannot be made with swimmers and water polo players because of the differences that exist between the sports, particularly the added overhead throwing activity of water polo players. Because of the increased repetition in water sports compared to baseball and tennis, stresses placed on the shoulder between these overhead sports are quite different.

Examination of Swimmers and Water Polo Players

Swimmers and water polo players incur many of the same injuries as other overhead athletes, such as baseball and tennis. Swimming and water polo players inherently repeat overhead action with each stroke during practice. This intense training level leads to overuse injuries of the shoulder. Overuse types of shoulder injuries, such as muscle strains, tendonitis, and impingement are very common to both swimmers and water polo players (Dominguez, 1986).

The two main orthopedic problems in the throwing athlete appear to be a combination of impingement and instability. Due to the combination of swimming and throwing in water polo players, the treatment of shoulder pain may be much more difficult (Dominguez, 1986). Stresses during the throwing phase of water polo can cause repeated microtrauma leading to labral changes and stretching of the glenohumeral ligaments (Copeland, 1993). The summation of swimming, throwing, and physicality of the game make water polo one of the most demanding sports played today (Dominguez, 1986).

Magnusson et al. (1995) studied masters level swimmers to determine internal and external rotation strength ratios in both arms. The study revealed that the men were significantly stronger than the women in both internal and external rotation; however, there were no statistical side-to-side strength differences in both the males and females. This data is important because it demonstrates a lack of arm dominance in water sports as opposed to other sports. Thus, internal and external rotation strength can be extrapolated to the opposite side.

McMaster et al. (1991) studied elite level water polo players. The water polo players were tested against a control group and were found to be significantly stronger than the controls (see Table 6). Muscle imbalance in the rotator cuff was reported in the water polo players and is significant because muscle imbalance predispose athletes to injuries. The differences were more significant at slower isokinetic speeds, with no side-to-side differences being noted.

Table 6.

Mean Values (%) and Standard Deviations of Adduction and abduction in External and Internal Rotation Ratios in the control and polo groups

Motion	Control (N=10)	Polo (N=15)
Adduction:Abduction		
30 deg/sec		
Right	1.53 ±0.12	1.79 ±0.34
Left	1.44 ±0.19	1.87 ±0.32
180 deg/sec		
Right	1.70 ±0.25	2.07 ±0.66
Left	1.58 ±0.25	2.00 ±0.50
External:Internal		
30 deg/sec		
Right	0.74 ±0.11	0.61 ±0.13
Left	0.78 ±0.11	0.61 ±0.08
180 deg/sec		
Right	0.65 ±0.14	0.55 ±0.15
Left	0.66 ±0.13	0.56 ±0.09

Note. From McMaster, 1991

The limited amount of research into internal and external rotation strength levels in water polo players and swimmers leaves many unanswered needs for the rehabilitation and prevention of injuries in these athletes. Studies have suggested a difference between the internal and external rotation of water sports and other overhead sports, and differences between male and female swimmers; however no studies have examined male and female swimmers and water polo players to determine internal and external rotation strength differences in these two sports. This study aims to identify strength values of internal and external rotation in the shoulder in females, and ascertain if a difference exists in the rotation strengths of swimmers and water polo players.

Chapter III

Methods

The purpose of this study is to see if a difference exists in internal and external rotation peak torque and total work values between female swimmers and water polo players. This section is divided into the following sections: subjects and sampling, testing apparatus, testing phase, and statistical analysis.

Subjects and Sampling

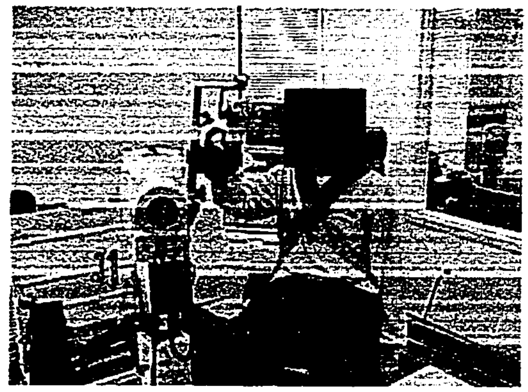
Ten female collegiate varsity swimmers and fifteen female collegiate varsity water polo players (n=25) from a Division 1A university will be chosen to serve as subjects. All subjects will sign a consent form (see Appendix A) prior to testing. Each subject will have their dominant shoulder tested. Hand dominance will be determined in water polo players by identifying the arm with which they throw and in swimmers by identifying the hand with which they write. Subjects will be excluded if they suffer from an existing shoulder injury or have had a significant shoulder injury requiring extensive rehabilitation or surgery in the past year (12 months).

Testing Apparatus

Each subject will have their shoulder tested for strength and power in internal rotation and external rotation on the Biodex, System 2 (Medical Systems Inc., Shirley, New York) isokinetic testing device. The Biodex will be calibrated regularly during testing according to the set standards in the Biodex, System 2 handbook. The subjects will be tested for strength at 60 degrees per second, endurance at 240 degrees per second, and a sport specific speed of 450 degrees per second. The subjects will be tested in the scapular plane and at 45 and 90 degrees of shoulder abduction (see Figures C and D).

Figures C. and D.

45 and 90 degrees of shoulder abduction in the scapular plane



Testing

Warm-up Phase

All subjects will be tested in loose-fitting clothes (athletic shorts and T-shirts) to eliminate shoulder restrictions during testing. The testing sequence will begin with a five-minute warm-up either on the Upper Body Ergometer (UBE) at 60 revolutions per minute or testing will take place immediately following a work out. The subjects will be positioned into the Biodex after this initial warm-up is completed.

Testing Phase

Each subject will be tested in the seated position and secured to the Biodex chair. The subjects will be secured to the chair with straps across the waist and across the tested shoulder to eliminate accessory trunk movement. The tested arm will be fitted into the dynamometer arm on the Biodex according to the Biodex testing protocol with the shoulder internal and external rotation attachment. The elbow will be stabilized with velcro straps and flexed to 90 degrees (see Figure E).

Figure E.

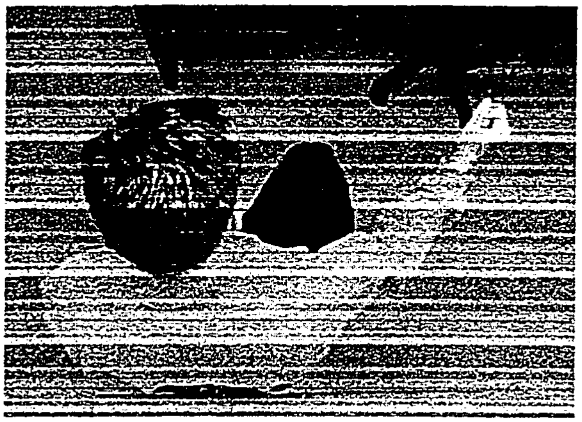
Stabilization of the Elbow with velcro straps

The uninvolved arm will remain in the neutral position at the subject's side during testing

Verbal instructions explaining the testing procedure will be given. Each subject will be given a countdown from 3 before the start of each test. Verbal cues will be given to the subject to encourage maximum effort. Each subject will perform concentric contractions of internal rotation and external rotation at each test speed and degree of shoulder abduction. Internal rotation is measured from the arm in the plane of the scapula until it approximates with the trunk and external rotation is measured from the arm in the plane of the scapula until it reaches its anatomical limit (see Figure F).

Figure F.

External Rotation in the Scapular Plane



The subjects will perform 5 repetitions at 60 degrees per second and 15 repetitions at 240 degrees per second. Both of these sets will be tested in 45 and 90 degrees of shoulder abduction with a one-minute rest period between tests.

Statistical Analysis

All data will be collected and stored in the Biodex, System 2 computer. Confidentiality will be maintained indicating only the subjects' sport. The Biodex computer will be used to print the test record and each data sheet will be solely identified as swimmer or water polo player.

Descriptive statistics will be used to determine the mean and standard deviation of the peak torque and total work values produced by each muscle group (internal/external rotators) at each speed and degree of shoulder abduction. Four independent t-tests will be calculated on the internal and external rotation peak torque and total work values between the swimmers and water polo players. An alpha level of less than 0.125 will be considered significant. The height, weight, and age of the subjects will be analyzed using descriptive statistics. Each subject will be tested twice and a reliability coefficient will be calculated.

Article Submission

The article will be written according to the author's notes and be submitted to the Journal of Athletic Training (see Appendix B).

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APPENDIX A

Informed-Consent Form

Internal and External Rotation Strength Values of Female Swimmers and Water Polo Players

1. Christopher Ferry, ATC who is a Graduate Assistant at San Jose State University has requested my participation in a research study at this institution. The title of the research is "Internal and External Rotation Strength Values of Collegiate Swimmers and Water Polo Players".
2. My participation in the study will involve an isokinetic test on the Biodex, System 2 of my dominant shoulder. The duration of the test will be approximately 20 minutes.
3. I understand there are foreseeable risks of discomforts to me if I agree to participate in the study. The only risk of participation in this study would be muscle soreness 1-2 days following testing.
4. I understand that the results of this research may be published but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Christopher Ferry, ATC will only use the codes of male and female and swimmer and water polo player. The tester, Christopher Ferry, ATC, will be the only person who knows the names of the subjects.
5. I have been informed that I will not be compensated for my participation.
6. I have been informed that any questions I have concerning the research study or my participation in it, before of after my consent, will be answered by Christopher Ferry, ATC, or Serena Stanford, PhD, AVP of Graduate Studies and Research.
7. I understand that in case of injury, if I have questions about my rights as a subject/participant in this research, or if I feel I have been placed at risk, I can contact the Chair of Human Subjects Research Review Committee.
8. I have read the above information. The nature, demands, risks, benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me.

Subject's Signature ________________________________ Date________________

9. I certify that I have explained to the above individual the nature and purposes, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed that above signature.
10. These elements of informed consent conform to the Assurance given by San Jose State University to the Department of Human Performance to protect the rights of human subjects.
11. I have provided the subject/participant a copy of this signed consent document.

Signature of Investigator________________________________ Date________________

APPENDIX B

Journal of Athletic Training

Authors Notes

Authors' Guide

(Revised January 1998)

The mission of the *Journal of Athletic Training* is to enhance communication among professionals interested in the quality of health care for the physically active through education and research in prevention, evaluation, management, and rehabilitation of injuries.

SUBMISSION POLICIES

1. Submit one original and five copies of the entire manuscript (including tables and figures) to: *Journal of Athletic Training* Submissions, Hughston Sports Medicine Foundation, Inc, 6262 Veterans Parkway, PO Box 9517, Columbus, GA 31908. The term *figure* refers to items that are not editable, either halftones (photographs) or line art (charts, graphs, tracings, schematic drawings), or combinations of the two. A *table* is an editable item that needs to be typeset.
2. All manuscripts must be accompanied by a letter signed by each author and must contain the following statements: "This manuscript 1) contains original unpublished material that has been submitted solely to the *Journal of Athletic Training*, 2) is not under simultaneous review by any other publication, and 3) will not be submitted elsewhere until a decision has been made concerning its suitability for publication by the *Journal of Athletic Training*. In consideration of the NATA's taking action in reviewing and editing my submission, I the undersigned author hereby transfer, assign, or otherwise convey all copyright ownership to the NATA, in the event that such work is published by the NATA. Further, I verify that I have contributed substantially to this manuscript as outlined in item #3 of the current Authors' Guide." By signing the letter, the authors agree to comply with all statements. Manuscripts that are not accompanied by such a letter will not be reviewed. Accepted manuscripts become the property of the NATA. Authors agree to accept any minor corrections of the manuscript made by the editors.
3. Each author must have contributed to the article. This means that all coauthors should have made some useful contribution to the study, should have had a hand in writing and revising it, and should be expected to be able to defend the study publicly against criticism.
4. Financial support or provision of supplies used in the study must be acknowledged. Grant or contract numbers should be included whenever possible. The complete name of the funding institution or agency should be given, along with the city and state in which it is located. If individual authors were the recipients of funds, their names should be listed parenthetically.
5. Authors must specify whether they have any commercial or proprietary interest in any device, equipment, instrument, or drug that is the subject of the article in question. Authors must also reveal if they have any financial interest (as a consultant, reviewer, or evaluator) in a drug or device described in the article.
6. For experimental investigations of human or animal subjects, state in the "Methods" section of the manuscript that an appropriate institutional review board approved the project. For those investigators who do not have formal ethics review committees (institutional or regional), the principles outlined in the Declaration of Helsinki should be followed (41st World Medical Assembly. Declaration of Helsinki: recommendations guiding physicians in biomedical research involving human subjects. *Bull Pan Am Health Organ*. 1990;24:606–609). For investigations of human subjects, state in the "Methods" section the manner in which informed consent was obtained from the subjects. (Reprinted with permission of *JAMA* 1997;278:68, copyright 1997, American Medical Association.)
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10. Published manuscripts and accompanying work cannot be returned. Unused manuscripts will be returned if submitted with a stamped, self-addressed envelope.

STYLE POLICIES

11. Each page must be printed on one side of 8½ by 11-inch plain paper, double spaced, with one-inch margins. Do not right justify pages.
12. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:
    a. Title page
    b. Acknowledgments
    c. Abstract and Key Words (first numbered page)
    d. Text (body of manuscript)
    e. References
    f. Tables (each on a separate page)
    g. Legends to figures
    h. Figures
13. Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.
14. Units of measurement shall be recorded as SI units, as specified in the *AMA Manual of Style*, except for angular displacement, which should be measured in degrees rather than radians. Examples include mass in kilograms (kg), height in centimeters (cm), velocity in meters per second ($m \cdot sec^{-1}$ or m/sec), angular velocity in degrees per second ($° \cdot sec^{-1}$), force in Newtons (N), and complex rates (mL/kg per minute).
15. Titles should be brief within descriptive limits (a 16-word maximum is recommended). If a disability is the relevant factor in an article, the name of the disability should be included in the title. If a technique is the principal reason for the report, it should be in the title. Often both should appear.
16. The title page should also include the name, title, and affiliation of each author, and the name, address, phone number, fax number, and E-mail address of the author to whom correspondence is to be directed.
17. A structured abstract of 75 to 200 words must accompany all manuscripts. Type the complete title (but not the authors' names) at the top, skip two lines, and begin the abstract. Items that are needed differ by type of article. **Literature Review:** Objective, Data Sources, Data Synthesis, Conclusions/Recommendations, and Key Words; **Original Research articles:** Objective, Design and Setting, Subjects, Measurements, Results, Conclusions, and Key Words; **Case Reports:** Objective, Background, Differential Diagnosis, Treatment, Uniqueness, Conclusions, and Key Words; **Clinical Techniques:** Objective, Background, Description, Clinical Advantages, and Key Words. For the Key Words entry, use three to five words that do not appear in the title.
18. Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly stated and developed. Tell why the study needed to be done or the article written and end with a statement of the problem (or controversy). Highlights of the most prominent works of others as related to your subject are often appropriate for the introduction, but a detailed review of the literature should be reserved for the discussion section. In a one- to two-paragraph review of the literature, identify and develop the magnitude and significance of the controversy, pointing out differences among others' results, conclusions, and/or opinions. The introduction is not the place for great detail; state the facts in *brief* specific statements and reference them. The detail belongs in the discussion. Also, an overview of the manuscript is part of the abstract, not the introduction. The active voice is preferred. For examples, consult the *AMA Manual of Style*.
19. The body or main part of the manuscript varies according to the type of article (examples follow); however, the body should include a discussion section in which the importance of the material presented is discussed and related to other pertinent literature. Liberal use of headings and subheadings, charts, graphs, and figures is recommended.
    a. The body of an **Original Research** article consists of a methods section, a presentation of the results, and a discussion of the results. The methods section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics and a few well-planned and carefully constructed illustrations.
    b. The body of a **Literature Review** article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so that they progressively focus on the problem or question posed in the introduction.
    c. The body of a **Case Report** should include the following components: personal data (age, sex, race, marital status, and occupation when relevant—but not name), chief complaint, history of present complaint (including symptoms), results of physical examination (example: "Physical findings relevant to the rehabilitation program were . . ."), medical history (surgery, laboratory results, exam, etc), diagnosis, treatment and clinical course (rehabilitation until and

Authors' Guide

after return to competition), criteria for return to competition, and deviation from expectations (what makes this case unique).

d. The body of a **Clinical Techniques** article should include both the *how* and *why* of the technique: a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations, and an explanation of why the technique should be used. The discussion concerning the *why* of the technique should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison with other techniques.

20. Communications articles, including official Position Statements and Policy Statements from the NATA Pronouncements Committee; technical notes on such topics as research design and statistics; and articles on other professional issues of interest to the readership are solicited by the *Journal*. An author who has a suggestion for such a paper is advised to contact the Editorial Office for instructions.
21. The manuscript should not have a separate summary section—the abstract serves as a summary. It is appropriate, however, to tie the article together with a summary paragraph or list of conclusions at the end of the discussion section.
22. References should be numbered consecutively, using superscripted arabic numerals, in the order in which they are cited in the text. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.
23. References to articles or books, published or accepted for publication, or to papers presented at professional meetings are listed in numerical order at the end of the manuscript. Journal title abbreviations conform to *Index Medicus* style. Examples of references are illustrated below. See the *AMA Manual of Style* for other examples.

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    Books:
    1. Fischer DH, Jones RT. *Growing Old in America*. New York, NY: Oxford University Press Inc; 1977:210–216.
    2. Spencer JT, Brown QC. Immunology of influenza. In: Kilbourne ED, Gray JB, eds. *The Influenza Viruses and Influenza*. 3rd ed. Orlando, FL: Academic Press Inc; 1975:373–393.

    Presentations:
    1. Stone JA. Swiss ball rehabilitation exercises. Presented at the 47th Annual Meeting and Clinical Symposia of the National Athletic Trainers' Association; June 12, 1996; Orlando, FL.
24. Table Style: 1) Title is bold; body and column headings are roman type; 2) units are set above rules in parentheses; 3) numbers are aligned in columns by decimal; 4) footnotes are indicated by symbols (order of symbols: *, †, ‡, §, ‖, ¶); 5) capitalize the first letter of each major word in titles; for each column or row entry, capitalize the first word only. See a current issue of the *Journal* for examples.
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27. Legends to figures are numbered with Arabic numerals in order of appearance in the text. Legends should be printed on separate pages at the end of the manuscript.

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

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